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# Optimal prediction of coastal acid sulfate soil severity using geographic information systems

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# Optimal Prediction of Coastal Acid Sulfate Soil Severity using Geographic Information Systems

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**CERTIFICATION**

I, Marcus J. Morgan declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Engineering (Honours), in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Marcus J. Morgan

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## Abbreviations

| | |
|---|---|
| ACASS | Actual Coastal Acid Sulfate Soil |
| AGD | Australia Geodetic Datum |
| AHD | Australian Height Datum |
| Al | Aluminium |
| ALS | Airborne Laser Scan |
| AMG | Australian Map Grid |
| ANOVA | Analysis Of Variance |
| ANS | Australian National Spheroid |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| ARMCANZ | Australian Resource Management Council of Australian and New Zealand |
| ASRIS | Australian Soil Resource Information System |
| Cl:SO4 | Chloride:Sulfate |
| CANSIS | Canadian Soil Information System |
| CASS | Coastal Acid Sulfate Soils |
| CASSOK | Coastal Acid Sulfate Soils Ordinary Kriging Model |
| CEC | Cation Exchange Capacity |
| CIS | Commonwealth of Independent States |
| CLT | Central Limit Theorem |
| DEM | Digital Elevation Model |
| DTM | Digital Terrain Model |
| EAA | European Environment Agency |
| EC | Electrical Conductivity |
| EM | Electromagnetic Survey |
| ESB | European Soil Bureau |
| EGII | European Geographic Inform Infrastructure |
| ESRI | Environmental Systems Research Institute |
| EU | European Union |
| EUSIS | European Union Soil Information System |
| ExAl | Exchangeable Aluminium |
| Fe | Iron |
| GCS | Geographic Coordination System |
| GDA | Geocentric Datum Australia |
| GIS | Geographic Information Systems |
| GPI | Global Polynomial Interpolation |
| GPS | Global Positioning System |
| GWR | Geographically Weighted Regression |
| FAO | Food and Agriculture Organization |
| IDW | Inverse Distance Weighting |
| ISG | Integrated Survey Grid |
| KCl | Potassium Chloride |
| LIDAR | Light Detection And Ranging |
| LPI | Local Polynomial Interpolation |
| LRR | Land Resource Region |
| LRRC | Land Resources Research Centre |
| LRU | Land Resource Unit |
| MGA | Map Grid Australia |
| MLRA | Major Land Resource Area |

| | |
|---|---|
| NASIS | National Soil Information System |
| NRCS | Natural Resource Conservation Service |
| NSW | New South Wales |
| OK | Ordinary Kriging |
| PCASS | Potential Actual Coastal Acid Sulfate Soil |
| PCS | Projected Coordination System |
| pH | $\log_{10}(H^+)$ |
| RBF | Radial Basis Function |
| REMS | Reclaimed Water Management System |
| RMSPE | Root Mean Square Prediction Error |
| RMSS | Root Mean Squared Standardised |
| RV | Representative Value |
| Spocas | Sulfate – |
| Scr | Sulfur-Chromium Reducible |
| SAI | Space Applications Institute |
| SALIS | Soil and Land Information System |
| SOTER | Soil and Terrain Database |
| SPADE | Soil Profile Attribute Data Environment |
| SRADWG | Shoalhaven River Acid Drainage Working Group |
| SRTW | Self Regulating Tilting Weir |
| SSIS | Spanish Soil Information System |
| SSSD | State Soil Survey Database |
| SSURGO | Soil Survey Geographic database |
| STATSGO | State Soil Geographic database |
| SQL | Structured Query Language |
| TAA | Total (Titratable) Actual Acidity |
| TF | Thiobacillus Ferroxidans |
| TPA | Titratable Peroxide Activity |
| UK | Universal Kriging |
| USDA | United States Department of Agriculture |
| UTM | Universal Transverse Mercator |
| VIF | Variance Inflation Factor |

**Abstract**

Coastal Acid Sulfate Soil (CASS) is a soil-water phenomenon that causes soil and water pollution resulting from the exposure, typically human-initiated, of pyrite to atmospheric and biotic oxygen. Structural deformation of capital works, combined with loss to flora and fauna (biodiversity) resulting from CASS has caused major concern to environmental managers, industries that rely directly on high quality water conditions for day-to-day operations, and landholders who experience characteristic scalding and other associated environmental problems on land adjacent to disturbed areas.

Areas of CASS in Australia have been identified by Department of Natural Resources (DNR) using a combination of expert knowledge, geomorphologic principles and Geographic Information Systems (GIS) known as Acid Sulfate Soil Risk Maps. These maps have been applied by local managers in planning and natural resource management to identify areas showing the highest probability of being severely affected by CASS.

In this project, with the DNR model as a starting point, the aim was to improve the way CASS severity is assessed. This included using five major soil-chemical parameters and/or relationships in a number of geostatistical models. The five parameters included were: Total Actual Acidity (TAA), pH, Chloride to Sulfate ratio ($Cl^-$:$SO_4^{2-}$), Depth to actual CASS layer (Jarosite layer), and Exchangeable Aluminium per cent of total Cation Exchange Capacity. Other parameters such as depth to Potential CASS layer (Pyrite layer) and Sulfur per cent (S%), also have weight but not as significant as the other parameters and were subsequently removed from further detailed analysis.

Ordinary Kriging (OK) was identified as the most suitable geostatistical method to predict CASS severity using the aforementioned soil-chemical principles. The resulting 3-Dimensional model was compared to the 2-Dimensional DNR Risk Maps with similarities in both models validating both approaches in determining severity using different methods. The CASSOK model put a greater emphasis on soil parameters down the soil profile and how they relate to surface elevation across a finite study area (Broughton Creek floodplain, New South Wales).

Applying the new CASSOK model to broader areas of New South Wales will be dependent on available data to input into the model. Using the current DNR risk maps is a broad indication of an area, using CASSOK will give a greater indication of what can be expected 2m below the surface. The ability to create a method that can be applied across the entire state of New South Wales, and then to a national level will be an invaluable resource to land managers in future planning and risk management.

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Soy Terminar! Gracias mi amore.

**Dedication**

This is dedicated to all the research students that undergo serious difficulties in trying to complete a research document due to reasons out of their control, I understand your grief.